

# **Review of the California Ambient Air Quality Standard for Nitrogen Dioxide**

**February 22, 2007**

**Board Hearing**

**Sacramento, California**



**Air Resources Board**

**California Environmental Protection Agency**

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Thank you Ms. Witherspoon.

Good morning Chairman Sawyer and members of the Board.

This morning we are presenting Staff's recommendations for amending the ambient air quality standard for nitrogen dioxide or NO<sub>2</sub>. The recommendations are the result of a critical review of the scientific literature on the health and welfare effects of NO<sub>2</sub> by the staff of the Air Resources Board (ARB) and the Office of Environmental Health Hazard Assessment (OEHHA).

# Overview

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- Criteria for standard setting
- Process for standard setting
- Sources and levels of NO<sub>2</sub>
- Health effects of NO<sub>2</sub>
- Basis for the standard recommendations

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For this presentation, we'll provide a brief discussion of the NO<sub>2</sub> standard review, focusing on these five principal areas:

We will discuss the criteria for standard setting and the standard setting process.

We will then briefly discuss the findings of the standard review, including the sources and levels of NO<sub>2</sub>, and the health effects of this pollutant.

Finally, we will discuss the basis for our recommendations to revise the current standard.

# Criteria for Standard Setting

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We'll begin with a discussion of what is an ambient air quality standard, and why are reviewing the NO<sub>2</sub> standard.

# Elements of an Ambient Air Quality Standard

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- Air Quality Standard: legal definition of clean air
- Standards have:
  - Pollutant definition
  - Concentration
  - Averaging time
  - Monitoring method
  - Form of the standard
- Based solely on health & welfare

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An ambient air quality standard is the legal definition of clean air under California law. It represents our best estimate of the highest exposure that would not likely lead to adverse health effects.

Standards have five elements.

First, they include a definition of the pollutant, in this case NO<sub>2</sub>.

They also include a concentration such as micrograms per cubic meter or parts per million, an averaging time, such as one-hour, a monitoring method to determine concentrations, and the form of the standard such as “not to be exceeded”

Standards are based solely on health and welfare effects.

## Standard Setting Does Not Include

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- Attainment designation plans
- Feasibility of controls
- Cost of controls
- Implementation of controls
- Separate regulatory process to address control issues

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California standard setting does not include consideration of the following:

Standards do not include plans for attainment, they are the goals to which attainment plans aim.

Standard setting also does not include the feasibility of controls, the cost of controls or the implementation of controls.

However, these issues are addressed through a separate regulatory process when specific control methods are proposed.

## Why Did We Review the NO<sub>2</sub> Standard ?

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- Protect public health
- Comply with State law
- Address requirements of Children's Environmental Health Protection Act (SB25, Escutia, 1999)
- Priority for review based on Children's Environmental Health Protection Act evaluation

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We reviewed the State NO<sub>2</sub> standard because State law requires that ambient air quality standards protect public health, and that they be periodically reviewed to ensure that the most recent scientific information is considered.

Further, this standard was reviewed to address the requirements of the Children's Environmental Health Protection Act of 1999, or SB25.

This Act required that ARB and OEHHA evaluate a number of air pollution issues, including the adequacy of ambient air quality standards to protect public health, especially that of infants and children. In the year 2000, ARB and OEHHA staff evaluated all existing health-based ambient air quality standards to determine whether there was evidence that they might not adequately protect public health. The results of this evaluation identified NO<sub>2</sub> as a priority for full review.

## Why Are We Concerned about NO<sub>2</sub>?

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- Current standard not adequate to protect public health, including infants and children
- Adverse health effects related to NO<sub>2</sub>
- Children, asthmatics most vulnerable
- NO<sub>2</sub> commonly found pollutant in outdoor air
- Higher concentrations reported near roadways

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As will be discussed later in this presentation, our critical review of the scientific literature showed that the current standard is not adequate to protect public health. It further shows a number of potential adverse health effects to the public, with children and asthmatics being the most vulnerable.

Also, NO<sub>2</sub> is a commonly found pollutant in outdoor air and even higher concentrations have been reported near sources such as roadways and freeways.

## Staff Recommendations for the NO<sub>2</sub> Standard

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- Reduce level of current 1-hr standard from 0.25 ppm to 0.18 ppm, not to be exceeded
- Establish a new annual average standard of 0.030 ppm, not to be exceeded
- Retain current monitoring method (gas phase chemiluminescence)

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Staff's recommendations regarding the NO<sub>2</sub> standard are summarized here.

Reduce the current 1-hour standard of 0.25 ppm, to 0.18 ppm, not to be exceeded.

Establish a new annual average standard of 0.030 ppm, not to be exceeded

And, retain the monitoring method of chemiluminescence for NO<sub>2</sub>.

These recommendations are based on clinical human studies, epidemiological studies, and supportive laboratory studies. Details of these studies will be summarized by Dr. Ostro later in this presentation.



## NO<sub>2</sub> Standards (ppm)

	One Hour	Annual
California (current)	0.25	--
US EPA	--	0.053
California (proposed)	0.18	0.030
<i>WHO Guidelines</i>	<i>0.106</i>	<i>0.021</i>

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To put these recommendations in perspective, this slide lists the current state and National standards for NO<sub>2</sub>. The Federal Clean Air Act allows California to set its own air quality standards, in consideration of statewide concerns. The current California State one-hour NO<sub>2</sub> standard is 0.25 ppm, and was last reviewed in 1992.

The current national ambient air quality standard for NO<sub>2</sub> is an annual standard of 0.053 ppm. It was initially adopted in 1971 and last reviewed by EPA in 1995.

Finally, the World Health Organization (WHO) has recommended guidelines for NO<sub>2</sub>. The World Health Organization is the United Nations specialized agency for health. The WHO air quality guidelines are designed to offer guidance in reducing the health impacts of air pollution and are intended to inform policy-makers and to provide appropriate targets for a broad range of policy options for air quality management in different parts of the world.

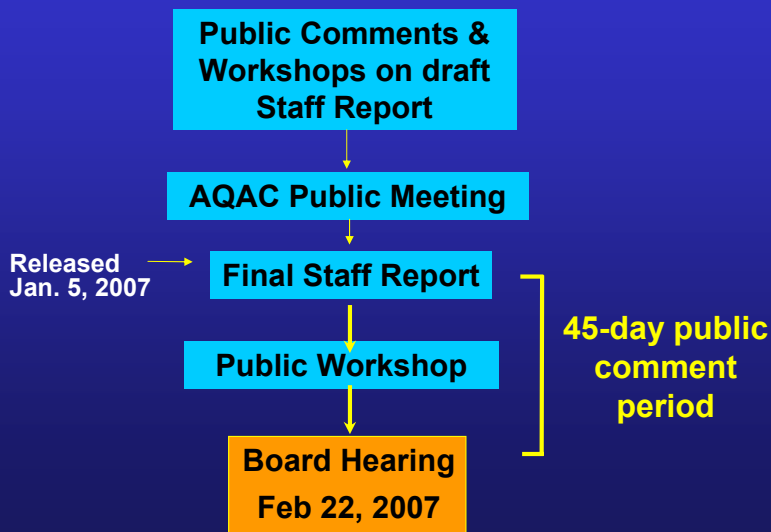
# Process for Standard Setting

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I would now like to discuss the process for reviewing and recommending changes to the ambient air quality standard for NO<sub>2</sub>

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## What Are the Regulatory Steps in a Standard Review?



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Briefly, after a critical review of the scientific literature, ARB and OEHHA staff, with the assistance of expert consultants, prepared a draft Staff Report and Technical Support Document. These reports were released to the public for review and comment and Public workshops were conducted to discuss the review.

Next, the Air Quality Advisory Committee, or AQAC, peer reviewed the draft NO<sub>2</sub> reports during a public meeting in June of last year.

All public comments on the draft reports were considered by AQAC in their peer review process. The public also submitted comments at the AQAC meeting for the Committee's consideration. AQAC then submitted the findings of their peer-review to the ARB in writing.

The Staff Report was revised after the AQAC review in response to public comments and AQAC findings, and a revised Final Staff Report was published with a 45-day public comment period prior to this presentation to Board.

## **Air Quality Advisory Committee (AQAC) Review**

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- Peer review required
- Appointed by University of California President
- Purpose of AQAC review:
  - Assess adequacy of scientific basis for proposed standards
  - Assess adequacy of proposed standards to protect public health

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Peer review of the proposed standards is mandated by provisions of the California Health and Safety code. The Air Quality Advisory Committee, is appointed by the Office of the President of the University of California. Each member is an expert of one or more aspects of the report or Technical document.

The purpose of AQAC's peer review is to assess the completeness and conclusions of staff's scientific review on which the proposed standards are based. The committee also evaluates whether the proposed standards are supported by the findings of the literature review, and whether the proposed standards adequately protect public health.

## Findings of the AQAC Review

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- Scientific conclusions and findings are consistent with the available data
- Staff recommendations are scientifically sound, and justified
- Suggested clarifications and discussion, additional references, and additional information in some sections of the report
- Staff made revisions based on AQAC review

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At the end of their 2 day public meeting conducted last June, AQAC indicated that the scientific conclusions and findings presented in the staff report are consistent with the available data.

AQAC further found that the staff recommendations are scientifically sound and well justified.

The committee made a number of suggestions for changes to the staff report, largely oriented toward more detailed discussion on or clarification of several topics, and requested the addition of several references.

The committee unanimously endorsed the proposed revisions to the State NO<sub>2</sub> standard.

Staff revised the staff reports based on AQAC suggested revisions, and a revised version of the staff report was released on January 5<sup>th</sup> of this year.

More details of the AQAC findings will be presented by Dr. Kleinman at the end of the staff presentation.

# Staff Findings

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- Sources and Levels of NO<sub>2</sub>
- Health Effects
- Basis for recommendations

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I would now like to summarize staff findings as presented in the Staff Report, first focusing on sources, emissions, and air quality information.

The remainder of the presentation will focus on the health effects of NO<sub>2</sub> and the basis for staff's recommendations.

## Sources of NO<sub>2</sub>

- Product of high temperature combustion
  - Power plants, motor vehicles
  - NO<sub>x</sub> (NO + NO<sub>2</sub>) emitted from sources
- Product of atmospheric processes
$$\text{NO} + \text{O}_3 \longrightarrow \text{NO}_2$$
- Indoor pollutant
  - Gas appliances, unvented heaters

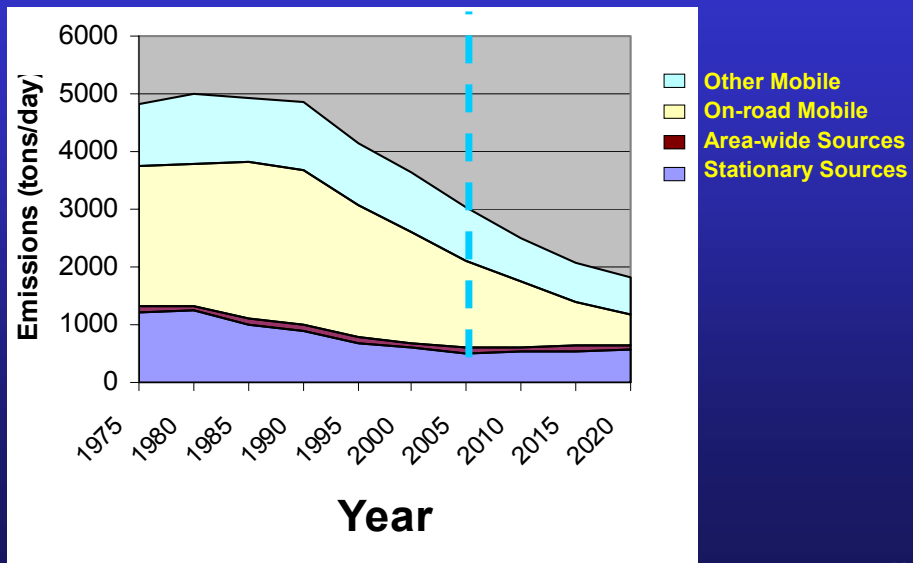
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With respect to the sources of NO<sub>2</sub>, this pollutant is typically formed from high temperature combustion of fuels such as those used in power plants and motor vehicles. Combustion leads to the emission of oxides of nitrogen, known as NO<sub>x</sub>, which consists primarily of nitric oxide (NO) and some NO<sub>2</sub>.

Also, most of the emitted nitric oxide is converted to NO<sub>2</sub> through a number of atmospheric reactions. For example, here, we see the formation of NO<sub>2</sub> from the reaction of nitric oxide (NO) with ozone (O<sub>3</sub>).

It should be noted that NO<sub>2</sub> is also present in indoor environments, typically associated with the use of gas stoves and unvented space heaters.

## Oxides of Nitrogen (NO<sub>x</sub>) Emissions Trends Statewide Annual Average (tons/day)



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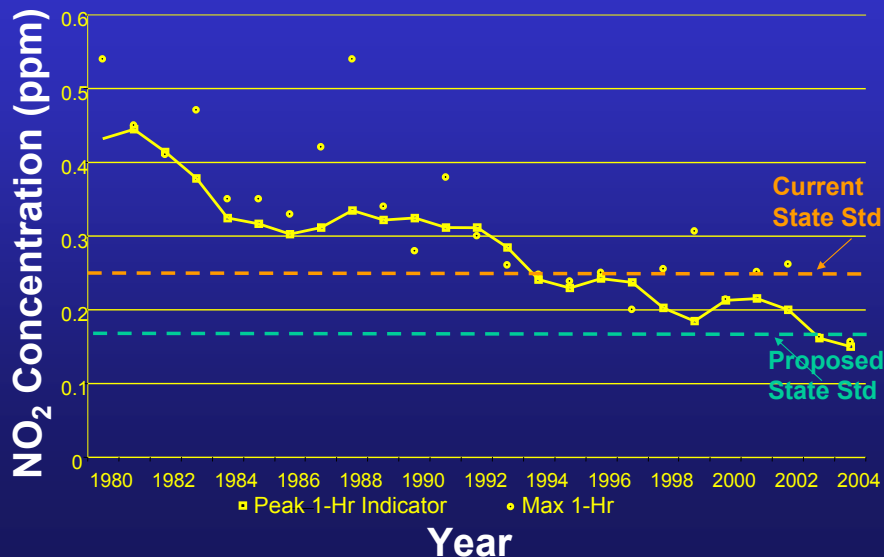
As mentioned in the previous slide, NO<sub>2</sub> is both directly emitted and is also a byproduct of atmospheric reactions of nitric oxide.

This figure illustrates the emission trends of NO<sub>x</sub> by source category, expressed as tons per day. Notable is that mobile sources (depicted in the light blue and in yellow) are responsible for the majority of the total statewide NO<sub>x</sub> emission in 2004. The darker blue on the bottom of the figure represents emissions from stationary sources.

As seen here, the NO<sub>x</sub> emissions from mobile sources have been decreasing over the last two decades, and are expected to continue to decrease in the future. The blue dashed vertical line indicates the year 2005.



## South Coast Air Quality Trends One-hour NO<sub>2</sub> (ppm)

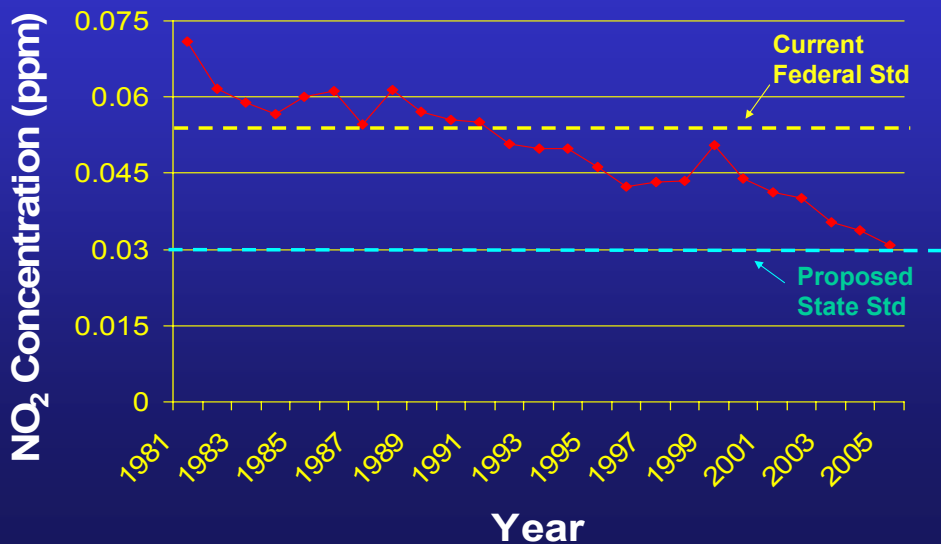


The long term reductions in NO<sub>x</sub> emissions as seen in the previous slide, are reflected in a similar reduction in ambient NO<sub>2</sub> concentrations.

This figure shows the airborne concentrations of NO<sub>2</sub> in ambient air and its decrease over the years in the South Coast Air Basin, California's largest metropolitan region. More specifically, the data shown here is from the Burbank station. The solid line is a statistically calculated value to determine improvements in air quality, while the individual dots are maximum values reported.

The South Coast air basin has come a long way in reducing NO<sub>2</sub> levels. For example, in 1988, the maximum 1-hr concentration was 0.54 ppm, more than double the State 1-hr standard. In 2004, it had declined steadily to 0.157 ppm. The current State one hour standard of 0.25 ppm is indicated by the dashed orange line, and the proposed standard of 0.18 ppm is indicated by the dashed green line.

## South Coast Air Quality Trends Annual Average NO<sub>2</sub> (ppm)



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Just as the one-hour average has decreased over the last two decades, so too has the annual average NO<sub>2</sub> concentration.

This chart summarizes the annual average NO<sub>2</sub> concentration observed over the years in the South Coast Air Basin. Each dot is the maximum annual average for the South Coast air basin. The green dashed line is the proposed annual average standard and the yellow dashed line is the current Federal annual standard. As can be seen, the concentrations reported during the early 1980s were more than double the concentration currently reported.

## Near Roadway Exposures

- Possible higher concentrations of NO<sub>2</sub> near roadways
- Some groups may be disproportionately exposed
  - Low income living near freeways
  - Children attending schools near roads
- Need to evaluate distribution of NO<sub>2</sub> monitoring sites
- Exposure characterization, not a health issue

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Staff also reviewed data on near-roadway exposures and found that NO<sub>2</sub> concentrations in ambient air may vary significantly. There is some evidence that the concentration of NO<sub>2</sub> outdoors can be considerably higher near heavily traveled roadways and freeways, than regional monitoring would indicate. These are possible “hotspots” for NO<sub>2</sub>.

Some investigators have reported that a higher percentage of minorities and people with lower income live or attend schools near busy roadways. Hence, these groups may experience higher levels of exposure than the general population of California.

For these reasons there needs to be a careful evaluation of the spatial distribution of the monitoring sites to determine if they adequately characterize exposures to NO<sub>2</sub>, especially for infants, children, and asthmatics.

This represents an exposure characterization issue, and so does not affect the health basis of the standard.

# Health Effects of NO<sub>2</sub>

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I would like to now turn over the presentation to Dr. Ostro who will begin summaries of the health effects of NO<sub>2</sub>.

Dr. Ostro ...

## **Evidence on the Health Effects of NO<sub>2</sub> Provided from Different Types of Studies**

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- Controlled human exposure
- Animal toxicology
- Epidemiology

# Controlled Human Exposure Studies

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- Exposures of human volunteers in a laboratory setting
- Responses studied: respiratory symptoms, lung function, inflammation (lung or blood), cardiovascular effects
- Typical subjects: healthy adults or mild asthmatics

## Controlled Human Exposure Studies (con't)

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- Advantages
  - Precise measures of exposure and response
- Limitations
  - Few studies on more vulnerable populations
  - Small sample size and studied doses
  - Few studies of pollutant mixtures
  - Cannot predict effects of chronic exposures

## **Controlled Human Studies of NO<sub>2</sub>: Lowest Concentrations Showing Effects**

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- Healthy Subjects: no effects below 1 ppm
- Asthmatics
  - Enhanced response to inhaled allergen at 0.26 ppm (15-30 min)
  - Increased airway reactivity at 0.2 – 0.3 ppm (30 min-2 hr)
    - Potential to increase asthma symptoms and medication use

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## Controlled Human Studies (con't)

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- Subjects with chronic obstructive lung disease
  - Decreased lung function at 0.3 ppm
- Limited data for children, elderly and those with cardiovascular disease
- Other considerations:
  - Variability in response among subjects
  - Limited data on longer exposure durations and effects of NO<sub>2</sub> with co-pollutants

## Epidemiologic Studies of NO<sub>2</sub>

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- Examines effects of NO<sub>2</sub> in large human populations under real-world conditions
- Studies of acute effects
  - Time series – ↑ NO<sub>2</sub> from day to day and ↑ hospitalizations or death
  - Panel studies of asthmatic children
- Studies of chronic effects
  - Longer term exposures (months to years) and risk of disease

# Epidemiologic Studies

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- Advantages

- Evaluate exposures and responses of free-living populations over a wide range of individuals, behaviors, and subgroups, including susceptible individuals
- Examine both short and long-term exposures

- Limitations

- Difficult to determine relevant exposure averaging time
- Need to account for other factors such as co-pollutants

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# Findings from Epi Studies

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## Acute exposure to NO<sub>2</sub> (24-hr to several days)

- ER visits and hospital admissions, especially for asthma, most consistent for both adults and children.
- Increased symptoms and decreased lung function in panel studies of asthmatics
- Increased mortality, cardiovascular-related hospital admissions, cardiac arrhythmias

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# Findings from Epi Studies

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## Chronic exposure to NO<sub>2</sub> (and traffic) (months to years)

- Asthma exacerbations
- Reduced lung function and lung growth
- Low birth weight
- Respiratory symptoms

## Likely Effect Levels for NO<sub>2</sub> and Respiratory Disease

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- Time series studies linking NO<sub>2</sub> with emergency room visits and hospital admissions for asthma had long-term average of 0.03 - 0.05 ppm (24-hr avg)
- Several of these studies suggest an independent effect of NO<sub>2</sub>
- At these concentrations, studies also link chronic exposures (months to years) to NO<sub>2</sub> with loss of lung function and asthma symptoms

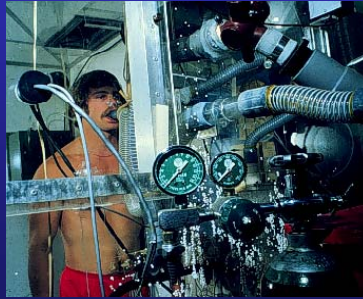
## Findings from Animal Studies

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- Prolonged repeated exposure of young animals during lung development show changes in lung structure ( $\geq 0.25$  ppm)
- In animal models of allergic asthma, exposure to high concentrations of  $\text{NO}_2$  ( $\geq 5$  ppm) produce consistent increased markers of allergic inflammation
- Animal studies suggest oxidant damage – consistent with human studies
- In terms of the amount of inhaled  $\text{NO}_2$  reaching the deep lungs, rodents inhaling 1 ppm  $\text{NO}_2$  is about equivalent to humans inhaling 0.25 ppm  $\text{NO}_2$

# Basis for Recommendations

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## **Basis for NO<sub>2</sub> 1-hour Standard of 0.18 ppm**

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1. Enhanced response to allergen in asthmatics at 0.26 ppm for 15-30 min
2. Increased airway reactivity in asthmatics at 0.25 - 0.3 ppm for 30 min- 1 hr

## Basis for NO<sub>2</sub> 1-hour Standard (con't)

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3. Add margin of safety for:
  - Children and other susceptible populations (e.g. more severe asthmatics)
  - Possible effects at lower concentrations
  - Proposing 1-hr avg standard but effects observed after 15-30 minutes
4. Effects observed in epidemiologic time-series and panel studies may be due to short-term exposures

## **Basis for Annual Average Standard of 0.030 ppm**

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1. Hospital admissions and ER visits for asthma, and effects on lung development and asthma exacerbation in areas with annual averages of 0.025 to 0.040 ppm
2. Potential effects of NO<sub>2</sub> on serious outcomes including mortality, ER, hospitalization for cardiac and respiratory disease and arrhythmias
3. NO<sub>2</sub> likely to be best marker of traffic among criteria pollutants

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## Basis for Annual Average (con't)

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4. Studies show airway reactivity and enhancement of allergic response and alterations in lung structure in young animals due to long term exposures
5. Important to lower full distribution of exposures not just peak 1-hr

## **SB 25 Requires Special Considerations for Infants and Children**

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- Exposure patterns: higher exposures per body weight and more time spent outdoors
- Susceptibility: exposure may impact lung development and function
- Pollutant interactions: little evidence at this point

# Summary of Staff Recommendations

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## Summary Staff Recommendations for Nitrogen Dioxide

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- Retain Nitrogen Dioxide as the pollutant definition
- Reduce the current 1-hr standard to 0.18 ppm, not to be exceeded
- Establish a new annual average of 0.030 ppm, not to be exceeded
- Retain the chemiluminescence monitoring method

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Staff's recommendations regarding the NO<sub>2</sub> Standard are summarized here.

- Reduce the current 1-hour standard of 0.25 ppm, to 0.18 ppm, not to be exceeded based on recent health studies that will be reviewed here today.
- Establish a new annual average standard of 0.030 ppm, not to be exceeded
- Finally, retain the monitoring method of chemiluminescence for NO<sub>2</sub>.

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**California Environmental Protection Agency**

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I would like to thank you for your attention. We would be pleased to answer any questions you may have.